"*Polytremacis* and the Ancestry of Helioporidæ." By Professor J. W. Gregory, D.Sc. Communicated by Professor Ray Lankester, F.R.S. Received November 21,—Read December 7, 1899.

[Plate 2.]

Contents.

1. Introduction.

The Blue Coral, *Heliopora cærulea* (Pall.) is one of the most isolated of living animals. It is the only known species of its genus, and it has recently been described as the only member of its family. Some Palæozoic corals have a very similar structure; but the view that these extinct Heliolitids are allied to the Helioporids is strongly opposed by some eminent palæontologists. If these authorities be right, then *Heliopora* is an animal with no close living relations and with no known ancestors.

The only fossil that has been regarded with any probability as a possible link between *Heliopora* and the extinct Heliolitidæ is the Cretaceous coral *Polytremacis*. This genus was founded by d'Orbigny in 1849, but unfortunately its affinities and structures are still in doubt. "If a genus ever was in need of revision," recently exclaimed Professor Lindström [1899, **9**, 28], "it is this." Lindström indeed suggests that distinct genera are required for each of von Reuss' three species of *Polytremacis*.

Without a study of type-specimens in several Continental museums, a final revision of the genus is impossible for three reasons. The characters of *Polytremacis bulbosa* d'Orb., the species on which the genus was originally established, are quite unknown; there is one uncertain feature in *P. blainvillei* (Mich.), the acting type species; and doubts have been expressed as to the accuracy of von Reuss' figures of the specimens which he identified as *P. blainvillei*. But in preparing a description of a new species of *Heliopora* from Somali-land, I have been led to examine the material in the British Museum collection. The

results seem to confirm the old view of the affinity between the Heliolitidæ and the Helioporidæ, by showing that *Polytremacis* is truly intermediate between the two families. In that case *Polytremacis* is of considerable phylogenetic interest as an ancestor of *Heliopora*. I therefore venture to submit this paper to the Society which has published the two most important contributions to our knowledge of that important coral.

2. The Type of Polytremacis.

Polytremacis was founded by d'Orbigny in 1849, when he gave it the following very inadequate diagnosis [**14**, p. 11]:—" c'est un *Stylophora* sans saillies aux calices, ceux-ci simplement creusés. Intervalle d'un tissu poreux, granuleux en dessus. Ensemble amorphe." The only species named is *P. bulbosa* d'Orb. from the Cenomanian of the Ile d'Aix, Charente-Inférieure; it was defined the following year [**15**, p. 183] as " espèce globuleuse, arrondie à calices assez grands." That species has never been figured, and the type specimen is apparently not available, as Milne Edwards and Haime [**5**, p. 232] who quoted it, have simply repeated d'Orbigny's statement. *P. bulbosa* may therefore be dismissed as a *nomen nudum*, and another type must be found for the genus. This task is easy. D'Orbigny's second reference to *Polytremacis* was in his 'Prodrome de Paléontologie,' where (vol. 2, p. 209) he gives a list of four species. The first of the four is the *Heliopora blainvillei* of Michelin [**10**, p. 27, Plate 7, fig. 6], from the Turonian of Vaucluse. The other three were new species founded by d'Orbigny, apparently on mere varieties of *P. blainvillei*. The three new species were not figured, and were subsequently accepted by Milne Edwards and Haime on d'Orbigny's authority. There can therefore be no question that of these four species *P. blainvillei* (Mich.) must be taken as the type of *Polytremacis*.

The characters of this species are, however, somewhat doubtful. Michelin's original figure represented a lobed corallum, with one short cylindrical branch; the calicles are generally crowded and separated by areas about as wide as themselves. The rim of the calicle is notched by a series of sixteen or twenty teeth.

In 1854 von Reuss [**16**, p. 136, Plate 24, figs. 4–7] figured a coral from the Turonian of Gosau, and identified it as *P. blainvillei*. Milne Edwards and Haime [**5**, p. 232], to whom Michelin's types were easily accessible, accepted the accuracy of the determination, and described von Reuss' figures as " very good." But Lindström not only denies the accuracy of the specific identification, but urges that the coral is generically distinct from *Polytremacis* [**9**, p. 28].

The *Polytremacis blainvillei* of Michelin differs from that of von Reuss in two respects. The coral thus named by the former author has no lamellar septa, but only a series of " pseudosepta " or septal

teeth; in the coral figured by von Reuss, each calicle has from eight to fourteen lamellar septa. The second difference is much less important, and consists in the more crowded arrangement of the calicles in Michelin's type of the species; but the distribution is not uniform in Michelin's specimen, and varies enormously in a series of specimens from the Turonian of the Bouches-du-Rhône recently received by the British Museum. The difference in the septa is, however, more significant; that the septa in some of the Gosau *Polytremacis* are lamellar is shown by Lindström's own description of a specimen sent him from Vienna. It does not seem to me necessary to regard the difference as of generic value; but it certainly seems reasonable to treat it as a specific distinction, and I therefore propose to name the Gosau specimens with long septa *Polytremacis septifera*.

The type species of *Polytremacis* is therefore *P. blainvillei* (Mich.) *non* Reuss.

3. The Structure of Polytremacis.

Corallum.—The corallum is irregularly lobed, or grows in thick cylindrical branches. The whole surface is granulated. The calices are crowded (*P. blainvillei*) or widely and irregularly separated (*P. partschi*). The greatest separation is due to the closure of dead calicles by growth of cœnenchymal cæca (as in *Heliolites interstinctus*; Lindström, **9**, Plate 1, fig. 21). This closure is illustrated by a figure of two calicles of *P. macrostoma* (Plate 2, fig. 1).

Thin sections show that the corallum is deeply excavated by large cylindrical calicles, the walls of which are smooth or fluted. In typical calicles the walls are thick; but young calicles and some internal ones may remain in a thin-walled *Heliopora* stage (Plate 2, fig. 3). The calicles are surrounded by narrow cæca, which are circular or elliptical in section. The cæca may be irregular in arrangement, or occur in a circle round a calicle. Outgrowths from the cæca or from the calicle traverse the cæcal mass like canals.

Septal Structures or "*Pseudosepta.*"—The external rim of the calicle is marked by an irregular series of granules forming septal teeth like those of *Heliopora*, as, *e.g.*, in Michelin's original figure of *P. blainvillei*. These teeth may be continued down the sides of the calicles as continuous ridges, which may be few and long, as in *P. septifera*, or numerous and short, as in *P. blainvillei*. The septal ridges may be continued radially outwards; on the surface they then appear as lines of radial granules (Plate 2, fig. 1); internally, in thin sections, they appear as lamellæ, continued outward as costal lamellæ separating the cœnenchymal cæca. This arrangement is not shown in all sections; it is illustrated by Plate 2, fig. 4A. Lindström's figure of *Plasmopora suprema* shows a similar structure [**9**, Plate 7, fig. 24].

In the older parts of the calicles the septal structures are absent

and the calicular walls are plain, as in the corresponding stages of *Heliopora* (*cf.* **7**, Plate 13, fig. 4) and some *Heliolites* [**9**, Plate 2, figs. 16, 18, and 20].

The number of septal ridges and teeth is variable (as in *Heliopora*); the number is from 16 to 20 in *P. blainvillei* and from 8 to 20 in *P. septifera*.

Aureole.—The wall of the calicle may be thin in young and some internal calicles, but in mature calicles it is greatly thickened. It may be surrounded by an "aureole" (Lindström) of large cæca, with the walls continuous with the septa as in the Heliolitid *Plasmopora* (*cf.* Lindström's figure of *P. stella*, **9**, Plate 11, fig. 36).

Tabulæ occur across both the calicles and cœnenchymal cæca.

Baculi.—Rod-like pillars of compact, calcareous material, which Lindström has described in the Heliolitidæ, occur in *P. blainvillei*, as remarked by Lindström [**9**, p. 28].

4. The Affinities of Polytremacis.

A. *The Relations of the Helioporidæ and Heliolitidæ.*

The preceding account of the structure of *Polytremacis* shows that the coral consists of a series of tubes, which are marked internally by longitudinal ridges, are crossed by transverse tabulæ, and are separated by smaller cæcal tubuli. This structure agrees with that of both the living Helioporidæ and the Palæozoic Heliolitidæ, and the affinities of *Polytremacis* are clearly with one or other of those families.

We have, therefore, to consider the question whether the two families are themselves nearly related. All the older and many recent authorities regard them as intimately allied. Blainville, in 1834 [**2**, p. 392], included them both in the genus *Heliopora*. Dana, in 1848 [**4**, pp. 539–541], separated them generically, but left them in one sub-family—the Helioporinæ. Zittel, in 1879 [**20**, p. 212], Studer, in 1887 [**18**, p. 21], and Sardeson, in 1896 [**17**, p. 353], all included them in one family. Bourne, in 1895 [**3**], has warmly supported the view of the intimate alliance of the two groups. On the other hand the existence of any special affinity between the Helioporids and the Heliolitids is denied by Lindström [**9**, pp. 25–26], Hinde [**8**, p. 87], and Wentzel [**19**, p. 490]. It is not even always admitted that the corals belong to the same subphylum; for while *Heliopora* is unquestionably an Alcyonarian, according to F. Bernard [**1**, p. 187], the Heliolitidæ may be Hydrozoa.

The proposed separation of the Helioporidæ from the Heliolitidæ is based on two characters: (1) the presence of true septa in the latter and not in the former; (2) the absence from the Helioporidæ of the calicular theca of the Heliolitidæ.

To determine the affinities of *Polytremacis* we must appreciate these characters :—

B. *The Septal Structures.*—According to Dr. Hinde [**8**, p. 87], Neumayr [**11**, p. 320–1], and J. Wentzel [**19**, p. 490], *Heliolites* differs essentially from *Heliopora*, in the possession of definite septa, which those authors apparently regard as homologous with the septa of madreporarian corals. In *Heliopora* there are no such septa; the structures originally described as such are a series of teeth round the rim of the calicular tube; below each tooth a fluted ridge runs down the tube for some distance. Neumayr, in 1899, proposed for these ridges the name of "pseudosepta" [**11**, p. 306], and the term has been widely accepted; for, as Lindström remarks, the ridges are simply the projections of the cœnenchymal cæca.*

But the rule that the Heliolitids have septa and *Heliopora* has only "pseudosepta," is not absolute. Lindström has figured sections across *Heliolites* in which the septa are absent and the sections are identical with those of *Heliopora*. For instance, Lindström's figure [**9**, Plate 1, fig. 24] may be compared with a section of *Heliopora cærulea* figured in 1895 [**7**, Plate 63, fig. 4]. Both sections consist of crowded polygonal, thin-walled tubes, without any sign of septa or "pseudosepta." Moreover, Nicholson has figured a calicle of *Heliopora* in which the "pseudosepta" are more strongly developed than in the "septa" of some *Heliolites* [**12**, p. 333].

But it is by no means certain that there is any essential difference between the septa of *Heliolites* and the "pseudosepta" of *Heliopora*. According to Bourne the large calicles of *Heliopora* are formed by the fusion of nineteen cœnenchymal cæca into a single cavity. The fusion of the group of cæca is caused by the expansion of the central cæcum, which, as it grows, absorbs the adjacent parts of the surrounding cæca. The outermost parts of the walls between the six peripheral cæca remain for a time as radial septa; they are finally absorbed as the central cavity increases, and when it occupies the whole space of the group it is bounded by a plain wall. The various stages in this process may be seen along the growing edge of a lamellar corallum of *Heliopora*. It is illustrated by a series of four figures. Fig. 6*a* shows a group of tubes of which the central member is slightly larger than those of the surrounding series. There are no septa or septal ridges, and the arrangement is identical with that of a young *Heliolites* in the

* The structures are here described as septa, using the term in its descriptive sense. When the septa are greatly reduced they are referred to as septal ridges, analogous to the septal spines of Madreporaria. If the pejorative prefix be accepted in the one case, it ought to be in the others, and *Polytremacis* might be defined as a coral (or perhaps a pseudocoral) composed of pseudotheca, with a variable number of pseudosepta, separated by pseudocœnenchyma, traversed by pseudotabulæ, and with a basal deposit of pseudepitheca.

stage before the development of septa. The next figure (fig. 6*b*) shows a slight increase in the size of the central tube and reduction in that of the peripheral tubes. In the next stage (fig. 6*c*) the central tube is large, and is surrounded by a zone of compressed tubuli. Finally, there is the stage in which the septal structures appear. This stage is illustrated (fig. 6*d*) by a calicle with one well-developed septum, which is the continuation of the wall separating two adjacent tubuli.

That the calicles and septa of *Heliolites* are formed by the same process appears probable from evidence cited by Lindström, who has given a series of figures showing the development of a group of cæca into a large calicle, some of the cæcal walls remaining as septa (see Plate 2, fig. 7, *a–g*).

Hence it appears probable that the septa of *Heliolites* are not homologous with the septa of Madreporaria; for they are the remnants of walls and not special outgrowths from the margin of corallites. They are as much "pseudosepta" as the corresponding ridges in *Heliopora*. Why the septal structures are, as Professor Nicholson remarks, "approximately constant" in number and large in *Heliolites*, while they are small in size and variable in number in *Heliopora*, is easily explained. It is, in fact, the necessary consequence of the difference in size and regularity of the cœnenchymal cæca in the two genera. The cæca of *Heliopora* are relatively more numerous, smaller, and less regular than in *Heliolites*. Accordingly, as the calicle of *Heliopora* grows and absorbs the surrounding cæca, there is left a considerable and variable number of septal ridges.

That the cæca of the modern representatives of the Heliolitidæ should be smaller than those of the Palæozoic forms is not surprising. It is the natural line of development. *Heliopora* may therefore be explained as a Heliolitid in which the cæca have decreased in size and increased in number.

c. *The Calicular Theca of Heliolitidæ.*—According to Lindström, "the feature which decidedly removes it [*Heliopora*] far from the Heliolitidæ is the total want of a calicular theca." Professor Frech gives different expression to the same idea; he states [**6**, p. 500] that the walls of the calicles in *Heliopora* are perforated and incomplete, whereas those of *Heliolites* are complete, and the calicles are closed tubes. Frech's statement is, however, not correct, as a matter of fact [*cf.* Moseley, **13**, p. 112]; but his idea is apparently the same as that which has been so beautifully worked out by Professor Lindström.

Heliolites, according to Lindström, has a true theca,* which is the

* It may save some misunderstanding to remark that Lindström distinguishes three thecal structures: (1) the calicular theca which bounds the inner axial part of the calicle; (2) the external theca, which includes the calicular theca and all the cœnenchyma which has developed from it; and (3) the cœnotheca (*non* Bourne), which covers the lower part of the corallum like the epitheca of compound Madreporaria.

first part of the skeleton to be formed, and which persists in the adult as the calicular tube or inner tube of the calicle. In the development of a young *Heliolites* the thecal tube is first formed; when this tube is complete a series of septa develop from the inner walls of the tube, and then the cœnenchyma begins to form on the outer side of it.

Bourne, on the other hand, gives a very different explanation of the structure of the corallum, and holds that it is fundamentally the same in *Heliopora* and *Heliolites*, in both of which the calicle is bounded by a "cœnotheca," *i.e.*, a tube formed of the walls of a group of different elements in a colony, secondarily united into a single tube [**3**, p. 468].

Unfortunately nothing is known of the development of the primary calicle in *Heliopora*, so that no direct comparison of that stage in the two groups is possible. But the comparison of the formation of young calicles on the growing edges of *Heliopora* affords some suggestive hints. The young calicles in both genera pass through identical stages, which are represented for *Heliopora* by fig. 6, *a–d*, and for *Heliolites porosus* by fig. 7, *a–g*. In both cases the calicular theca of the complete calicle represents either the outer walls of the group of cæca which formed the calicle, or was formed by those outer walls being absorbed and re-deposited during the process of cœnenchymal gemmation.

A direct comparison of the development of the primary calicles in *Heliopora* and *Heliolites* would, no doubt, afford a better basis for an opinion than can be obtained from the development of young calicles in old coralla. But until zoologists work out the development of *Heliopora*, we can only appeal to the comparison of young equivalent calicles, and they develop on the same lines.

Hence, though nervous at differing from two such authorities as Professor Lindström and Dr. Hinde, I am bound to confess myself unconvinced that any essential difference between the Helioporidæ and Heliolitidæ has yet been established. Accordingly it is not unreasonable to expect in Mesozoic deposits some connecting links between the living and Palæozoic representatives of the group. *Polytremacis* appears to me to be such an intermediate form. *P. septifera*, with its eight to fourteen or twenty well-developed septa, agrees with *Heliolites*, differing by the less regularity in the number of septa. The Turonian *P. blainvillei* and the Eocene *P. bellardi* agree with *Heliopora*, as the septa are reduced to septal ridges.

If we place any species of *Polytremacis* in the Heliolitidæ,* that family can no longer be described as characterised by the possession of twelve septa. If, on the other hand, we place *P. septifera* in the Helioporidæ, we have to admit in that family the presence of septa as well-defined as they are in some Heliolitidæ. In either case the distinction between the two families, based on the septal characters,

* As suggested by Neumayr, **11**, p. 321.

has broken down. The only escape from this difficulty is the heroic course of dividing *Polytremacis* into two unrelated divisions, one species being regarded as an isolated, belated survivor of the Heliolitidæ, and another as a premature ancestor of the Helioporidæ.

Polytremacis agrees with the Heliolitidæ by many remarkable points of structure, such as the presence of the aureole, the closure of dead calicles by cœnenchymal overgrowth, and the inconstancy of the septa in the lower parts of the calicles. *Polytremacis* is allied to *Heliopora* by equally striking points of resemblance, such as the fluted calicular walls, with their numerous, irregular, septal ridges, the granular external surface with its circumcalicular ring of septal teeth. On the axiom that things that are allied to the same are allied to one another, the close affinity of *Heliopora* and *Heliolites* seems more probable than some palæontologists are inclined to admit. *Heliopora*, in fact, may have descended from the Heliolitidæ by the reduction in size and consequent increase in number and in variability of arrangement of the cœnenchymal cæca.

5. Systematic Synopsis.

ALCYONARIA.

Order.—Cœnothecalia, Bourne.

Family 1.—Heliolitidæ.

Definition.—Cœnothecalia with regular, well-developed septa, generally 12 in number in each calicle.

For subdivisions, see Lindström [**9**, pp. 35–37].

Family 2.—Helioporidæ.

Definition.—Cœnothecalia, with small, irregularly arranged cœnenchymal cæca, and a variable number of septa or septal ridges.

Genus 1.—Heliopora, de Blainville, 1834.

Definition.—Corallum of thick lobes or digitate fronds. Calicles thin walled. Septal ridges numerous, and always short.

Type Species. Millepora cærulea, Pallas, 1766. 'Elench. Zooph.,' p. 256.

Heliopora cærulea, Blainville, 1834. 'Man. Act.,' p. 392.

Recent. Indian Ocean.

Species 1.—Heliopora somaliensis, n.sp.

Characters.—Corallum massive. Calicles very small, being between 0·5 and 1 mm. in diameter. They are about 2 mm. apart. From 12–15 septal ridges, which are sometimes prominent and well-developed. Cœnenchymal cæca circular. (Plate 2, figs. 8*a–c*.)

Distribution.—Turonian, Uradu limestone. Uradu near the Rugga Pass, Somaliland. (The Rugga Pass is in 45° 22′ E. and 10° N.) Collected by Mrs. E. Lort Phillips. Type in British Museum, R4150.

Affinities.—The nearest ally of this species is *H. edwardsi* Stol., from which it differs by having smaller and less distant calicles, and some areas of angular pseudocæca.

Species 2.—HELIOPORA EDWARDSI Stoliczka, 1873. 'Pal. Ind., Cret. Fauna, S. India,' vol. 4, Part IV, p. 53, Plate 11, fig. 11.

Characters.—Corallum incrusting; calicles 1 mm. in diameter, and from 4 to 5 mm. distant. Cœnenchymal cæca numerous and minute. Septal ridges 18 in number.

Stoliczka describes this species as almost identical with *Heliopora cærulea.*

Distribution.—Cenomanian. Utatur Group. E. of Kauray, S. India.

Species 3.—HELIOPORA BOETTGERI. Fritsch, 1878. "Kor. Nummulitensch. Borneo," 'Palæontogr.,' Suppl. III, Lief. 1, Part III, p. 103, Plate 17, fig. 4.

Characters.—Corallum a thin incrustation, 1 to 4 mm. thick. Calicles 1 mm. in diameter. Septal ridges, 16–24. Calicles widely spaced, with small, round cæca.

Distribution.—Eocene. Borneo.

Genus 2.—POLYTREMACIS, d'Orbigny, 1849.

Synonyms—

Heliopora, pars, Michelin, Edwards and Haime, *et alii.*

Dactylacis, d'Orbigny.

Definition.—Helioporidæ with thick-walled calicles.

Type Species.—*Heliopora blainvillei,* Michelin, 1841. 'Icon. Zooph., p. 27, Plate 7, fig. 6.

Affinities.—This genus is accepted by Milne Edwards and Haime, von Reuss, and Stoliczka for the Helioporids with long septa, which almost meet in the middle of the calicles. But von Reuss has remarked on the difficulty in using this uncertain character, and concludes that the separation of the genera is not based on any very firm ground.

The character of the calicular walls appears more reliable, especially as it appears to be geographically distinctive, *Heliopora* being limited to the Indian Ocean and Pacific, while *Polytremacis* occurs in the Upper Cretaceous and Lower Cainizoic of central Europe and France. The two genera seem very closely allied, and I should not be surprised if they are ultimately united.

Species 1.—POLYTREMACIS BLAINVILLEI (Michelin), 1841.

Synonymy,—Heliopora blainvilliana, Michelin, 1841. 'Icon. Zooph., p. 27, Plate 7, fig. 6.
non „ „ Quenstedt, 1852, 1867, 1880, and 1885.
Polytremacis „ d'Orbigny, 1850. 'Prod. Pal.,' vol. 2, p. 209.
„ „ Milne Edwards and Haime, 1851. "Polyp. palæoz.," 'Archiv. Mus. Hist. nat.,' vol. 5, p. 149.
non „ *blainvilleana*, von Reuss, 1854. "Kreid. Ostalp.," 'Denk. Akad. Wiss. Wien,' vol. 7, p. 131, Plate 24, figs. 4–7.
„ „ *pars*, Milne Edwards and Haime, 1860. 'Hist. nat. Cor.,' vol. 3, p. 232.
„ „ *pars*, Sardeson, 1896. "Bezieh. Tabul.," 'N. Jahrb.,' Beil. Bd. 10, pp. 261–262.
„ „ Lindström, 1899. "Heliolitidæ," 'Handl. k. Svensk. Vet.-Akad.,' vol. 32, No. 1, p. 28.

Characters.—Calicles very crowded over most of the corallum. Calicles 1–1·5 mm. in diameter. Septal ridges from 16 to 22; very short.

Distribution.—Turonian. Uchaux, Vaucluse.

Species 2.—POLYTREMACIS PARTSCHI, von Reuss, 1854.

Synonymy,—Polytremacis partschi, von Reuss, 1854. "Kreid. Ostalp.," 'Denk. Akad. Wiss. Wien.,' vol. 7, p. 131, Plate 24, figs. 1–3.
„ „ Sardeson, 1896. "Bezieh. Tabul.,' 'N. Jahrb.,' Beil. Bd. 10, p. 260.
Heliopora „ Milne Edwards and Haime, 1860. 'Hist. nat. Cor.,' vol. 3, p. 231.
„ „ von Zittel, 1879. 'Handb. Pal.,' vol. 1, p. 212, fig. 122.
„ *blainvilliana*, Quenstedt, 1852. 'Handb. Petref.,' p. 645, Plate 57, fig. 8.
„ „ Quenstedt, 1867. *Op. cit.*, edit. 2, p. 775, Plate 74, fig. 8.

Synonymy,—Heliopora blainvilliana, pars, Quenstedt, 1880. 'Petref. Deut.,' vol. 6, Part 11, p. 901, Plate 178, fig. 30, *non* 30*x*.
" " Quenstedt, 1885. 'Handb. Petref.,' p. 997, Plate 80, fig. 28.

Characters.—Calicles widely separated. They are from 1·5 to 2 mm. in diameter, and have from 24 to 28 septal processes. (Plate 2, figs. 2–4.)

Distribution—Turonian. Gosau, Wolfgangsee, and in Bouches-du-Rhône.

"*Angular Cæca.*"—von Reuss [**16**, Plate 24. fig. 3] has shown some angular cæca, which Lindström has referred to as stellate, and different from anything in *Heliopora*. A very similar arrangement occurs in patches in *Heliopora somaliensis* (*cf.* Plate 2, fig. 8*b*), where it is, however, clearly due to the inclusion of quartz-grains in the coral. The quartz-grains are scattered in patches, which sometimes (as in fig. 8*b*) cut abruptly across a calicle. In some cases these patches were clearly post-mortem in reference to the adjacent calicles, but were formed during the life of the corallum.

Species 3.—POLYTREMACIS MACROSTOMA, von Reuss, 1854.

Synonymy,—Polytremacis macrostoma, von Reuss, 1854. "Kreid Ostalp.," 'Denk. Akad. Wiss. Wien.,' vol. 7, p. 132, Plate 24, figs. 8–10.
" " Sardeson, 1896. "Bezieh. Tabul.," 'N. Jahrb.,' Beil. Bd. 10, p. 261.
Heliopora " Milne Edwards and Haime, 1860. 'Hist. nat. Cor.,' vol. 3, p. 232.
" *blainvilliana, pars*, Quenstedt, 1880. 'Petref. Deut.,' vol. 6, Part 11, p. 901, Plate 178, fig. 30*x*.

Characters.—Calicles 3 to 4 mm. in diameter, and surrounded by about 32 septal ridges. Calicles often widely spaced. (Plate 2, fig. 1.)

Distribution.—Turonian. Gosau.

Species 4.—POLYTREMACIS SEPTIFERA, n.sp.

Synonymy,—Polytremacis blainvilleana, von Reuss, 1854. "Kreid. Ostalp.," 'Denk. Akad. Wiss. Wien,' vol. 7, p. 131, Plate 24, figs. 4–7.

Synonymy,—Polytremacis blainvilliana, pars, Milne Edwards and Haime, 1860. 'Hist. nat. Cor.,' vol. 3, p. 232.

Characters.—Calicles well spaced and provided with from 8 to 20 (usually 8–14) long, well-developed septa. (Plate 2, figs. 5*a–b*.)

Distribution.—Turonian. Gosau.

Affinities.—This species is the most Heliolitoid member of the genus.

Species 5.—POLYTREMACIS BELLARDI, Haime, 1852.

Synonymy—

Polytremacis bellardi, Haime 1852. "Foss. Numm. Nice," 'Mém. Soc. géol. France,' Ser. 2, vol. 4, p. 289, Plate 22, fig. 7.
" " Milne Edwards and Haime, 1860. 'Hist. nat. Cor.,' vol. 3, p. 233.
" " d'Achiardi, 1868. 'Stud. Comp.,' pp. 30, 49.
" " " 1875. "Cor. eoc. Friuli," Part 3; 'Atti Soc. tosc. Sci. nat.,' vol. 1, p. 206.
Heliopora " von Reuss, 1874. 'Pal. Stud. ält. Tert. Alp.,' Part 3; 'Denk. Ak. Wiss. Wien,' vol. 23, p. 18, Plate 51, figs. 2, 3.
" " Oppenheim, 1896. "Eocaenf. M. Postale," 'Palæontogr.,' vol. 43, p. 143.
Millepora globularis, Catullo, 1856. 'Terr. sedimento sup. Venez.,' p. 78, Plate 17, fig. 9.
Heliopora " d'Achiardi, 1867. 'Cat. foss. terr. numm. Alpi Venete,' p. 11.

Characters.—Corallum, massive, lobed. Calicles very irregularly distributed. Septa from 16 to 20, and either short and reduced to septal ridges (*fide* von Reuss), or long, well-developed septa (*fide* Haime).

Distribution.—Eocene. N. Italy.

Genus OCTOTREMACIS, nov.

Synonym—

Polysolenia (*non* Ehrenberg, 1860), von Reuss, 1866. "Foss. Kor. Java": 'Novara Reise, Geol. Th.,' vol. 2, Part 2, p. 172.

Characters.—Helioporidæ with large, well-developed septa, typically eight in each calicle; the septa appear to occur in two cycles.

Type Species.—*Polysolenia hochstetteri*, von Reuss, 1866, *op. cit.*, p. 172, Plate 2, fig. 3.

Distribution.—Miocene. Tjukang Raon, Java.

The type specimen seems to have undergone a double change in fossilisation, and the material injected into the cavities of the coral has been represented by von Reuss as the actual skeleton.

Miscellaneous Indeterminable Species.

(?) *Heliopora mammillosa*, *Millepora mammillosa*, d'Achiardi, 1867. 'Catal. foss. terr. numm. Alpi Venete,' p. 11; von Reuss, 1869. "Pal. Stud. Alt. Tert. Alp.," Part 2; 'Denk. Akad. Wiss. Wien,' vol. 29, p. 352, Plate 27, figs. 4, 5.

Polytremacis bulbosa, d'Orbigny, 1850. 'Prod. Pal.,' vol. 2, p. 183.

,, *complanata* ,, ,, *op. cit.*, p. 209.

,, *glomerata* ,, ,, ,, p. 209.

,, *micropora* ,, ,, ,, p. 209.

,, *provencialis* (,,) ,, ,, p. 209.

,, *ramosa* (,,) ,, ,, p. 183.

,, *subramosa* (,,) ,, ,, p. 209.

,, *supracretacea*, d'Orbigny, 1850. "Foss. Danien." 'Bull. Soc. géol. France,' Ser. 2, vol. 7, p. 134.

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13.* H. N. Moseley. "On Helioporidæ and their Allies," '"Challenger" Reports,' Zool., vol. 2, 1881, pp. 102–126, Plates 1, 2.

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EXPLANATION OF PLATE 2.

Fig. 1. *Polytremacis macrostoma*, Reuss. Turonian. Gosau. B.M., 55824. Part of the external surface of a corallum, showing two calicles partly obliterated by cœnenchymal gemmation, and also radial lines of external granules, × 3 diam.

Fig. 2. *Polytremacis partschi*, Reuss. Turonian. Russbach, near Gosau. B.M., 56,820. Part of transverse horizontal section showing a thick-walled calicle, and the boring of a Leucodorite; × 10 diam.

[As the geological history of the Polychæta is necessarily very imperfect, it is interesting to note the commensalism of a fossil worm with *Polytremacis* analogous to that of *Leucodora* with *Heliopora cærulea*; as no anatomical comparison between the recent and fossil worms is possible, it is advisable to refer to the latter simply as Leucodorites.]

Fig. 3. *Polytremacis partschi*, Reuss. Turonian. Gosau. B.M., R4149. Transverse section across an internal calicle in the *Heliopora* stage, × 10 diam.

Fig. 4*a–b*. *Polytremacis partschi*, Reuss. Turonian. Bouches-du-Rhône. B.M., R2788.

„ 4*a*. Transverse section showing thick calicular wall and radial "costal" arrangement of lamellæ. × 10 diam.

„ 4*b*. A transverse section across a primitive cæcal group. × 15 diam.

Fig. 5*a–b*. *Polytremacis septifera*, n.sp.; copied from Reuss (16), Plate 24, figs. 4 and 5.

„ 5*a*. Portion of a corallum, natural size.

„ 5*b*. Portion of the outer surface, enlarged.

Fig. 6*a–d*. *Heliopora cærulea* (Pall.). Recent. B.M., Zool. Dept. Four parts of a growing edge of a lamellar corallum, surface views. × 10 diam.

„ 6*a*. A group of cæca, all subequal in size.

„ 6*b*. A group with enlarged central cæcum.

„ 6*c*. A young calicle and zone of reduced cæca.

„ 6*d*. An older calicle with septal ridges.

Fig. 7*a–g*. *Heliolites porosus* (Goldf.). Devonian. Seven stages in the development of a calicle by the fusion of a group of cæca. (After Lindström.) × 10 diam.

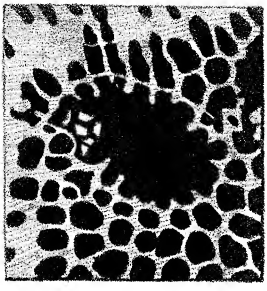
„ 7*a*. A group of cæca.

„ 7*b*. The same slightly developed.

„ 7*c*. The same after the cæcal walls have become thinner by partial absorption.

„ 7*d*. The same after absorption of the walls of the central cæcum forming a calicle made from eight cæca; the cæcal walls remain as septa.

Gregory.



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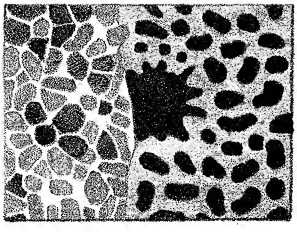

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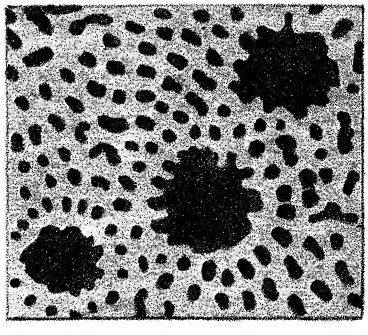

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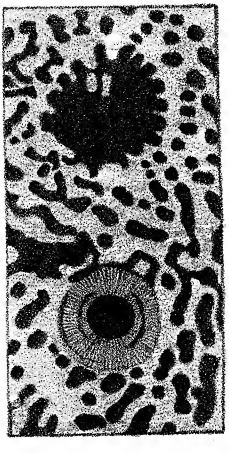

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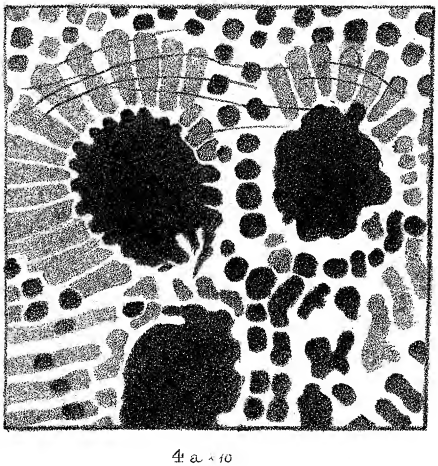

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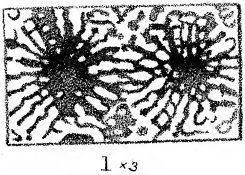

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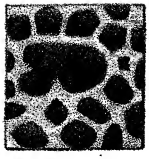

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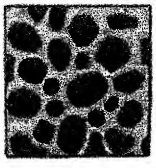

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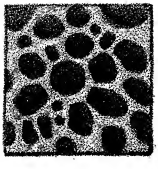

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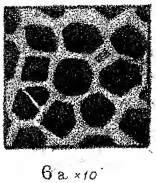

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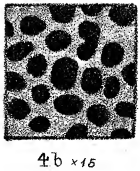

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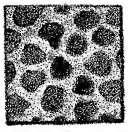

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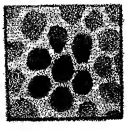

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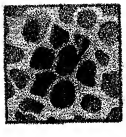

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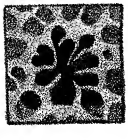

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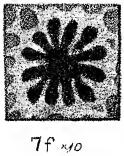

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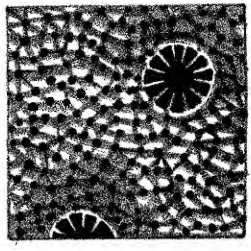

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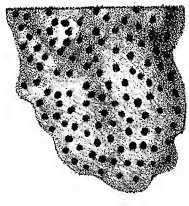

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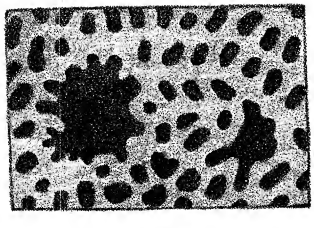

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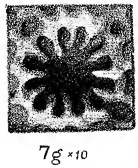


7g ×10

West, Newman imp.

„ 7*e*. The same still further developed and after the incorporation of some outer cæca.

„ 7*f*. A section across the complete calicle with its twelve well-developed septa.

„ 7*g*. The calicle as seen from the surface of the corallum.

Fig. 8*a–c*. *Heliopora somaliensis*, n.sp. Turonian. Uradu, Somaliland. B.M., R4150.

„ 8*a*. Part of a horizontal section with two calicles. × 15 diam.

„ 8*b*. Part of a horizontal section showing circular and angular "cæca," the latter being in the upper portion, which is filled with quartz-grains. × 10 diam.

„ 8*c*. Part of a horizontal section, showing three calicles, with and without septal ridges. × 15 diam.

On the Structure of Coccospheres and the Origin of Coccoliths."

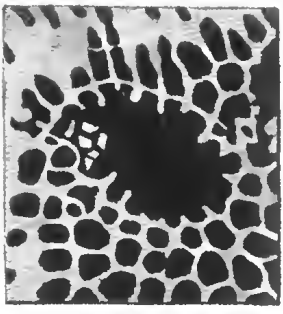
By Henry H. Dixon, Sc.D., Assistant to the Professor of Botany, Trinity College, Dublin. Communicated by J. Joly, F.R.S., Professor of Geology, Trinity College, Dublin. Received February 3,—Read February 22, 1900.

[Plate 3].

At the beginning of September last year, I visited Valencia, Co. Kerry. It occurred to me there that coccospheres might possibly be drifted in on the warm current of the Gulf Stream, which impinges on the south-west coast of Ireland, and as they float in would become entangled in the sea-weeds on the coast. With this idea, I gathered some of the finer marine algæ, such as species of Cladophora, Polysiphonia, and Plocamium, &c., from the rock pools in Valencia Harbour. Taking care to wash as little of the silt or sediment as possible from them, I fixed the mass in dilute formalin.

This method proved to be a most satisfactory way of collecting coccospheres and coccoliths. In the first sample of sea-weeds thus gathered at a venture, I obtained several hundreds of coccospheres, and of course innumerable coccoliths. In practice, the most convenient way of gathering coccospheres in abundance was found to be to collect the sea-weed, and there and then to wash the sediment from it in sea-water and formalin, or in alcohol, or in sea-water and osmic acid. The sediment which settles down in the fixing fluid will afterwards be found to contain large numbers of coccospheres. In preparations made from material collected in this manner, and mounted under a cover-glass 22 mm. × 22 mm., I have counted as many as fourteen coccospheres. Of course there are many other organisms present in addition to the coccospheres, *e.g.*, various crustacea, mites, worms, molluscs, foraminifera, infusoria, diatoms, peridineæ, &c.

I am indebted for most of the material from which the following



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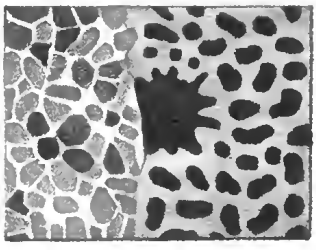

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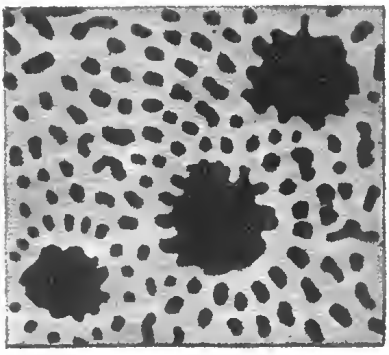

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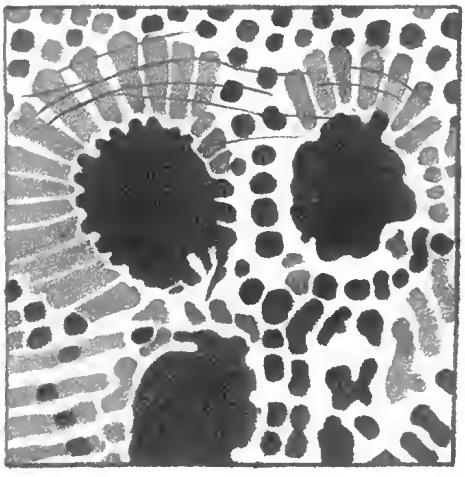

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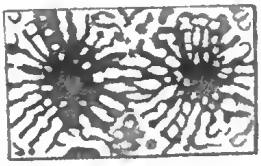

1 ×3

Fig. 1. *Polytremacis macrostoma*, Reuss. Turonian. Gosau. B.M., 55824. Part of the external surface of a corallum, showing two calicles partly obliterated by cœnenchymal gemmation, and also radial lines of external granules, × 3 diam.

Fig. 2. *Polytremacis partschi*, Reuss. Turonian. Russbach, near Gosau. B.M., 56,820. Part of transverse horizontal section showing a thick-walled calicle, and the boring of a Leucodorite; × 10 diam.

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Fig. 4*a-b*. *Polytremacis partschi*, Reuss. Turonian. Bouches-du-Rhone. B.M., R2788.

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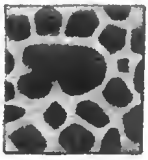
„ 8*b*. Part of a horizontal section showing circular and angular "cæca," the latter being in the upper portion, which is filled with quartz-grains. × 10 diam.

„ 8*c*. Part of a horizontal section, showing three calicles, with and without septal ridges. × 15 diam.



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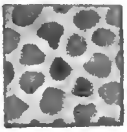

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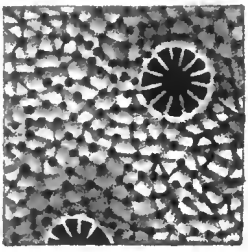

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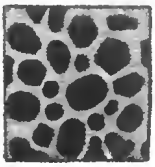

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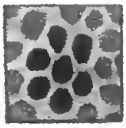

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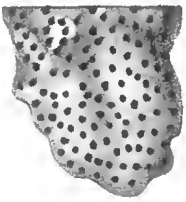

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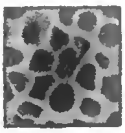

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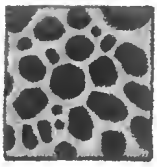

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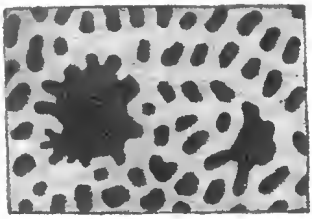

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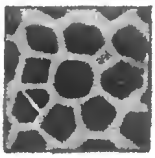
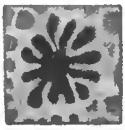
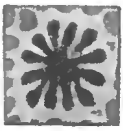


6a ×10



7e ×10

4b ×15



7f ×10

7g ×10

„ 4*b*. A transverse section across a primitive cæcal group. × 15 diam.

Fig. 5*a–b*. *Polytremacis septifera*, n.sp.; copied from Reuss (16), Plate 24, figs. 4 and 5.

„ 5*a*. Portion of a corallum, natural size.

„ 5*b*. Portion of the outer surface, enlarged.

Fig. 6*a–d*. *Heliopora cærulea* (Pall.). Recent. B.M., Zool. Dept. Four parts of a growing edge of a lamellar corallum, surface views. × 10 diam.

„ 6*a*. A group of cæca, all subequal in size.

„ 6*b*. A group with enlarged central cæcum.

„ 6*c*. A young calicle and zone of reduced cæca.

„ 6*d*. An older calicle with septal ridges.

Fig. 7*a–g*. *Heliolites porosus* (Goldf.). Devonian. Seven stages in the development of a calicle by the fusion of a group of cæca. (After Lindström.) × 10 diam.

„ 7*a*. A group of cæca.

„ 7*b*. The same slightly developed.

„ 7*c*. The same after the cæcal walls have become thinner by partial absorption.

„ 7*d*. The same after absorption of the walls of the central cæcum forming a calicle made from eight cæca; the cæcal walls remain as septa.

„ 7*e*. The same still further developed and after the incorporation of some outer cæca.

„ 7*f*. A section across the complete calicle with its twelve well-developed septa.

„ 7*g*. The caliole as seen from the surface of the corallum.

Fig. 8*a–c*. *Heliopora somaliensis*, n.sp. Turonian. Uradu, Somaliland. B.M., R4150.

„ 8*a*. Part of a horizontal section with two calicles. × 15 diam.